AMENDMENTS TO THE DRAWINGS

The attached three sheets of drawings includes changes to Fig. 1, Fig. 4, and Figs. 6a and 6b. These sheets, which include only Figs. 1, 4, and 6a and 6b, replace the original sheets including only Figs. 1, 4, and 6a and 6b. In Figs. 1, 4, and 6a and 6b, the jagged lines have been corrected. No new matter has been added.

Attachment: Three Replacement Sheets
Three Annotated Sheet Showing Changes

REMARKS

Claim status

Claims 1-23 were pending in the case at the time of the current Office Action. Claims 16, 19, and 20 are currently amended in the application. Claims 16, 19, and 20 have been amended herein simply to correct minor informalities. Claims 1-23 are currently pending in the application. New claim 24 has been added herein. Claims 1-24 are currently pending in the application.

Drawing rejections

In the current Office action, the official draftsperson has objected to the drawings due to jagged lines in Figs. 1, 4, 6a, and 6b.

Applicants respectfully traverse the foregoing objection in view of the above amended drawings and for reasons set forth hereafter.

The jagged lines of Figs. 1, 4, 6a, and 6b have been smoothed over herein. Three replacement sheets and three annotated sheets are provided herewith. No new matter has been added. Applicants respectfully request that the amended Figures be entered and that the objection be withdrawn.

Specification rejections

In the current Office action, the Examiner has objected to the specification because on page 3 in the detailed description of the invention paragraph [0018] the applicant states that the method disclosed is "conventional".

Applicants respectfully traverse the foregoing objection in view of the above amended paragraph and for reasons set forth hereafter.

Paragraph [0018] has been amended herein to change the word "conventional" to the intended word "proposed". Use of the word "conventional" in paragraph [0018] was the result of an unintended mistake in the specification. Applicants do not and never did intend to admit that each of the steps in paragraphs [0017] through [0019] in the detailed description of the

invention are prior art. No new matter has been added. Applicants respectfully request that the amended paragraph be entered and that the objection be withdrawn.

Section 102 rejections

In the current Office action, claims 1-10 and 12-20 are rejected under 35 U.S.C. 102(b) as being anticipated by Zhang et al. (U.S. Pat. No. 6,263,228).

Applicants respectfully traverse the foregoing rejections in view of the above pending claims and for reasons set forth hereafter.

Independent claim 1 recites a method of chemical species suppression for MRI imaging of a scanned object region comprising:

acquiring K space data at a first TE;

acquiring K space data at a second TE;

reconstructing images having off resonance effects;

estimating off resonance effects at locations throughout the reconstructed images; and

determining the first and second chemical species signals at image locations of the scanned object from the acquired signals and correcting for blurring resulting from off resonance effects due to B_o inhomogeneity.

It is respectfully submitted that Zhang et al. (U.S. Pat. No. 6,263,228), hereinafter Zhang, does not teach or suggest the invention of independent claim 1. In particular, Zhang at least does not teach or suggest acquiring K space data at a first TE and a second TE and correcting for blurring resulting from off resonance effects due to B_o inhomogeneity. Instead, Zhang describes using a 'single point Dixon method' which achieves water-fat signal decomposition using only one MR image at one TE. The Examiner's assertion that Zhang shows K space data being acquired at a first TE and a second TE in Figures 2a and 2b, as does the claimed invention, does not seem to be correct. Instead, Figures 2a and 2b of Zhang illustrate two separate pulse sequences for two different types of MR imaging.

The 'single point Dixon method' described in Zhang cannot precisely separate water-fat signals for voxels where both water and fat exist. If water (fat) is dominant over fat (water) in

particular voxels, the separated fat (water) image has zero signals in those voxels. Therefore, to perform accurate water-fat signal decomposition for voxels having both water and fat, at least two images with different TE's are needed.

Previously, the 'three point Dixon method' and the 'two point Dixon method' have been proposed in rectilinear data acquisition. These methods use three or two images with different TE's. Precise water-fat signal decomposition can be achieved even for voxels that contain both water and fat using these Dixon methods. This is because severe blurring effects are not typically present in rectilinear acquired data. All of the above previously proposed Dixon methods can be applied to the data that are acquired using rectilinear sampling methods. However, these methods cannot be applied in the same way to data that are acquired using spiral trajectories because signals are spread out due to off-resonance effects in the spiral images. These 'spread out' signals are usually perceived as 'blurring artifacts'. Blurring disrupts the phase relationship between water and fat signals in the spiral acquisitions.

In the claimed invention, 'Spiral Dixon techniques' overcome the disadvantage of the previously proposed Dixon methods in rectilinear acquisitions. The 'Spiral Dixon techniques' can achieve precise water-fat separation even if the decomposed images show blurring artifacts. Also, the blurring artifacts can be corrected (i.e., the images are de-blurred) on a pixel-by-pixel basis using the 'Spiral Dixon techniques' as described in the present application.

Zhang does not teach or suggest having to correct for blurring effects of any kind. Even where Zhang talks about the conventional multi-point Dixon methods in the background section, Zhang does not teach or suggest having to correct for blurring artifacts as part of or in addition to water-fat decomposition.

During spiral acquisition, blurring disrupts the phase relationship between water and fat signals, and it is this disrupted phase relationship that must be corrected. In the claimed invention, a frequency map is created (i.e., estimating off resonance effects at locations throughout the reconstructed image) and is applied to the data to correct for the blurring effects (i.e., to de-blur the water image and to de-blur the fat image). This frequency map is not the same as the map or image described in column 1 lines 15-29 of Zhang. Instead, the frequency map of the claimed invention is an estimate of off-resonance effects due to the blurring effects

from the spiral acquisitions. Zhang does not teach or suggest correcting for blurring effects caused by spiral acquisition or any other kind of acquisitions.

For example, using the 'Spiral 3-point Dixon method', a complete and correct frequency map is generated from the three acquired K space data sets at different TE's, and then water-fat decomposition is performed. Finally, blurring effects are corrected by applying the frequency map to the decomposed water and fat images.

As another example, using the 'Spiral 2-point Dixon method', several pre-determined frequencies are tried when performing water-fat decomposition and de-blurring. Then the best frequency for each location in the image is selected. In effect, the water-fat decomposition and de-blurring are performed at the same time for a given pre-determined frequency that is tried. This requires more processing time than the 'Spiral 3-point Dixon method', however, acquisition time is saved since only two K space data sets are acquired instead of three.

In summary, with rectilinear K space data acquisitions, decomposition into separate water and fat images is possible using the conventional Dixon techniques. The resultant decomposed water and fat images do not have to go through any additional process of de-blurring because, un-like spiral acquisitions, the data of the rectilinear acquisitions are not significantly spread out, causing blurring in the decomposed images. The water and fat images are simply corrected for normal B_0 inhomogeneities as part of the conventional decomposition process. However, with spiral acquisitions, additional processing steps are required to de-blur the decomposed water and fat images. Also, the claimed invention requires that at least two K space data sets be acquired. The focus of Zhang is using one acquired data set in a single-scan single-point Dixon method, even though Zhang does mention the conventional multi-point Dixon techniques in the background.

Therefore, in view of at least the foregoing, it is respectfully submitted that independent claim 1 is not anticipated nor rendered obvious by Zhang, and it is respectfully submitted that independent claim 1 defines allowable subject matter. Also, since claims 2-10 and 12-20 depend either directly or indirectly from claim 1, it is respectfully submitted that claims 2-10 and 12-20 define allowable subject matter as well. Applicants respectfully request that the rejection of claims 1-10 and 12-20 under 35 U.S.C. 102(b) be removed.

Section 103 rejections

In the current Office action, claims 1-3 are rejected under 35 U.S.C. 103(a) as being unpatentable over Tsai et al., US patent 6,215,306 (hereinafter Tsai) in view of Chen et al., US patent 6,084,408 (hereinafter Chen).

Also, in the current Office action, claims 1, 2, 5-9 are rejected under 35 U.S.C. 103(a) as being unpatentable over Tsai in view of Pauly et al., US patent 5,402,067 (hereinafter Pauly).

Furthermore, in the current Office action, claims 1-16, 22-23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Tsai.

Applicants respectfully traverse the foregoing rejections in view of the above pending claims and for reasons set forth hereafter.

Independent claim 1 recites a method of chemical species suppression for MRI imaging of a scanned object region comprising:

acquiring K space data at a first TE;

acquiring K space data at a second TE;

reconstructing images having off resonance effects;

estimating off resonance effects at locations throughout the reconstructed images; and

determining the first and second chemical species signals at image locations of the scanned object from the acquired signals and correcting for blurring resulting from off resonance effects due to B_o inhomogeneity.

It is respectfully submitted that neither Tsai, Chen, Pauly, nor any combination thereof teach or suggest the claimed invention. Tsai describes 'off-centered spiral trajectories'. Tsai is irrelevant to the claimed invention except that both applications use spiral trajectories. Tsai demonstrates that the images reconstructed from the data acquired using off-centered spiral trajectories exhibit less artifacts due to sampling time error than those reconstructed from the data acquired using regular centered spiral trajectories. Off-centered spiral trajectories are completely different from spiral off-resonance correction. Off-centered spiral trajectories are the

one type of spiral trajectories of which the center is shifted from the k-space origin. Spiral off-resonance correction is the method of the claimed invention to correct for blurring artifacts due to off-resonance effects. Also, Tsai has nothing to do with decomposition of data into water and fat images (i.e. chemical species suppression). Tsai does not teach or suggest applying multi-point Dixon techniques in any way to separate water and fat images, let alone to correct for blurring of such water and fat images.

Chen describes a method for determining intrinsic transverse relaxation time of a first mobile phase in a porous medium using nuclear magnetic resonance sequences. Chen is not at all concerned with chemical species suppression in the sense of the claimed invention. In fact, Chen is not concerned at all with imaging in the sense of the claimed invention. Chen is, instead, concerned with measuring an intrinsic relaxation time for determining fluid properties.

Pauly describes an imaging method using k-space spiral coverage. However, Pauly does not teach or suggest chemical species suppression by acquiring two or three sets of k-space data at different TE's and estimating off-resonance effects to correct for blurring as does the claimed invention. Instead, Pauly describes using transmit pulse techniques such as spatial-spectral pulse for excitation, inversion or excitation pulse, or 90-degree pulse pullback for lipid suppression (see column 4, lines 53-68). Similar conventional excitation pulse techniques were mentioned in the background section of the current application (SPSP, CHESS). The claimed invention does not use such excitation techniques but, instead, uses novel 'Spiral Dixon techniques' for chemical species suppression and de-blurring.

Applicants cannot see how Tsai, Chen, Pauly, nor any combination thereof would make the claimed invention of claim 1 be obvious to one skilled in the art. In fact, Tsai, Chen, and Pauly are not only highly unrelated to the claimed invention, they are highly unrelated to each other. Therefore, there would be no motivation for one skilled in the art to look at Chen and/or Pauly when considering Tsai, to look at Tsai and/or Pauly when considering Chen, or to look at Tsai and/or Chen when considering Pauly. The Examiner's attempts to relate various aspects of Tsai, Chen, and Pauly to the claimed invention seem unfounded.

In view of at least the foregoing, it is respectfully submitted that independent claim 1 defines allowable subject matter. Since claims 2-16 and 22-23 depend either directly or

indirectly from claim 1, it is respectfully submitted that dependent claims 2-16 and 22-23 define allowable subject matter as well. Applicants respectfully request that the rejections of claims 1-16 and 22-23 under 35 U.S.C. 103(a) be removed.

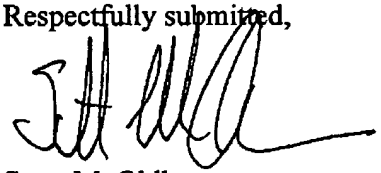
In the current Office action, claim 21 is rejected under 35 U.S.C. 103(a) as being unpatentable over Zhang.

It was previously established herein that claim 1 is neither anticipated nor rendered obvious by Zhang and that claim 1 defines allowable subject matter. Therefore, since claim 21 depends directly from claim 1, it is respectfully submitted that claim 21 defines allowable subject matter as well. Applicants respectfully request that the rejections of claim 21 under 35 U.S.C. 103(a) be removed.

Newly added claim 24 also distinguishes from the prior art for reasons similar to those set out with respect to claim 1. More specifically, claim 24 recites the steps of generating a frequency field map and performing a water-fat decomposition step to reconstruct a blurred water and fat image. The frequency field map is then applied to form deblurred images. This method is clearly not taught by the prior art, and favorable action thereon is requested.

Accordingly, the applicant respectfully requests reconsideration of the rejections and objections based on at least the foregoing. After such reconsideration, it is urged that allowance of all pending claims will be in order.

Respectfully submitted,



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